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PROGRESS THROUGH JULY 31, 1957

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Project Vanguard Staff

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PREVIOUS PROJECT VANGUARD REPORTS

Project Vanguard Report No. 1, "Plans, Procedures, and Progress" by the Project Vanguard Staff, NRL Report 4700 (Secret), January 13, 1956

Project Vanguard Report No. 2, "Report of Progress" by the Project Vanguard Staff, NRL Report 4717 (Confidential), March 7, 1956

Project Vanguard Report No. 3, "Progress through March 15, 1956" by the Project Vanguard Staff, NRL Report 4728 (Confidential), March 29, 1956

Project Vanguard Report No. 4, "Progress through April 15, 1956" by the Project Vanguard Staff, NRL Report 4748 (Confidential), May 3, 1956

Project Vanguard Report No. 5, "Progress through May 15, 1956" by the Project Vanguard Staff, NRL Report 4767 (Confidential), June 2, 1956

Project Vanguard Report No. 6, "Progress through June 15, 1956" by the Project Vanguard Staff, NRL Report 4800 (Confidential), June 28, 1956

Project Vanguard Report No. 7, "Progress through July 15, 1956" by the Project Vanguard Staff, NRL Report 4815 (Confidential), July 27, 1956

Project Vanguard Report No. 8, "Progress through August 15, 1956" by the Project Vanguard Staff, NRL Report 4832 (Confidential), September 5, 1956

Project Vanguard Report No. 9, "Progress through September 15, 1956" by the Project Vanguard Staff, NRL Report 4850 (Confidential), October 4, 1956

Project Vanguard Report No. 10, "Progress through October 15, 1956" by the Project Vanguard Staff, NRL Report 4860 (Confidential), November 4, 1956

Project Vanguard Report No. 11, "Progress through November 15, 1956" by the Project Vanguard Staff, NRL Report 4880 (Confidential), December 3, 1956

Project Vanguard Report No. 12, "Progress through December 15, 1956" by the Project Vanguard Staff, NRL Report 4890 (Confidential), January 16, 1957

Project Vanguard Report No. 13, "Progress through January 15, 1957" by the Project Vanguard Staff, NRL Report 4900 (Confidential), February 7, 1957

Project Vanguard Report No. 14, "Progress through February 15, 1957" by the Project Vanguard Staff, NRL Report 4910 (Confidential), March 12, 1957

Project Vanguard Report No. 15, "Progress through March 15, 1957" by the Project Vanguard Staff, NRL Report 4930 (Confidential), April 2, 1957

Project Vanguard Report No. 16, "Progress through April 15, 1957" by the Project Vanguard Staff, NRL Report 4950 (Confidential), May 1, 1957

Project Vanguard Report No. 17, "Progress through May 31, 1957" by the Project Vanguard Staff, NRL Report 4980 (Confidential), July 10, 1957

Project Vanguard Report No. 18, "Minitrack Report No. 1: Phase Measurement" by C. A. Schroeder, C. H. Looney, and H. E. Carpenter, NRL Report 4995 (Unclassified), July 26, 1957

Project Vanguard Report No. 19, "Progress through June 30, 1957" by the Project Vanguard Staff, NRL Report 5010 (Confidential), August 6, 1957

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An administrative report summarize progress on Project Vanguard with respect to —

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PREFACE

This report is intended as a general summary of the progress on Project Vanguard during the indicated period. Hence, minor phases of the work are not discussed to a great extent, and technical detail is kept at a minimum. It is hoped that the information here presented will be of assistance to administrative and liaison personnel in coordinating and planning their activities, and as a guide to the current status of the project. Material of a more technical nature will be published from time to time in separate reports which will be announced in subsequent monthly progress reports.

PROBLEM STATUS

This is an interim report; work on the problem is continuing.

AUTHORIZATION

NRL Problem A02-90

Manuscript submitted September 10, 1957

THE LAUNCHING VEHICLES

TEST PROGRAM

As a result of the successful flight of a prototype third-stage rocket (TV-1), it has become possible to revise the test program to provide complete Vanguard vehicle configurations earlier in the program. The test program heretofore called for a heavy instrumented nose cone on the third stage of TV-3; it is now planned to replace this with one of the 6.44-inch 6-antenna satellite packages and make TV-3 identical with TV-4. The performance of the third stage can then be inferred from the Minitrack records, which also afford a flight check of parts of the Minitrack system.

The small satellite package will be separated after third-stage burnout, and there is a small probability that it will orbit; thus a check of the entire Minitrack complex might be obtained, as well as some air density and ionospheric data. The package will be flown in all test vehicles except TV-5, which will test the separation at orbital height of a 20-inch sphere. The TV-3 backup and TV-4 backup vehicles are now definitely to be launched and are programmed into the flight schedule. The TV-2 backup vehicle, however, will be launched only in the event that TV-2 fails to meet its objectives.

The currently projected launching schedule is as follows:

Vehicle	Delivery Date at The Martin Co.	Launch Date at AFMTC
TV-3	9-13-57	10-30-57
TV-3BU	10-18-57	12-4-57
TV-4	11-22-57	1-15-58
TV-4BU	12-20-57	11-5-58
TV-5	1-17-58	3-5-58
SLV-1	2-14-58	4-9-58
SLV-2	3-14-58	5-14-58
SLV-3	4-11-58	6-18-58
SLV-4	5-9-58	7-23-58
SLV-5	6-6-58	8-27-58
SLV-6	7-3-58	10-1-58

DESIGN, STRUCTURE, AND ASSEMBLY

Testing of the redesigned roll jet assembly for TV-2 has been completed and the assembly has been shipped to the field. As soon as tests of the first-stage pressurization system are completed, the TV-2 backup vehicle will be shipped. The horizontal tests and second-stage vertical tests of TV-3 have been completed without difficulty. Early in August this vehicle, which has been modified to carry the 6.44-inch satellite instead of the original instrumented nose cone, will be erected for overall vertical checks at the Martin Co. plant. The TV-3 backup vehicle has been completed and the horizontal tests are now underway. Assembly of the first and second stages of TV-4 is continuing; however, the second-stage propulsion unit has not been delivered. The first-stage assembly and various subassemblies for the TV-4 backup vehicle have been started. Several first stage subassemblies for TV-5 are ready for splicing.

PROPULSION

First Stage

Two more X-405 powerplants (S/N-9 and S/N-10) have been accepted and delivered. The fifth powerplant, S/N-9, was delivered with only one performance deviation. This deviation, similar to that of S/N-8,* was a low instantaneous specific impulse value of 249 seconds. The overall impulse raised the average value to the acceptable minimum of 250 seconds. The sixth powerplant, S/N-10, gave an average specific impulse of 249 seconds. Testing has been initiated for the next engine, S/N-11, and acceptance firings should be completed in August.

The propellant expulsion tests on the first-stage pressurization mockup at The Martin Co. are almost completed; these tests involve the running of each system separately for orificing considerations. A complete rated-pressure expulsion test on the overall system is scheduled for early next period. Preliminary low pressure tests have indicated good performance.

Second Stage

The problem of erosion of the second-stage thrust chambers has not yet been fully resolved. After the failure of the thrust chamber during the first qualification test of the second-stage propulsion system,† another thrust chamber (C-10) was installed on the same tankage for another test series. This series was interrupted when the tankage ruptured after 170 seconds of firing time had been accumulated on the new chamber; the rupture was attributed to stress corrosion. A fire resulted but the thrust chamber was only slightly damaged, and repairs were made. Another propulsion unit (originally intended to be delivered as Propulsion Unit No. 3) was redesignated as the qualification test unit and the firings were resumed. The thrust chamber of this unit failed during the first full-duration firing because of erosion. The total firing time on the thrust chamber was 303 seconds but the failure is believed to have occurred at about 246 seconds. During this run, the solid charge which augments the helium pressure failed to ignite, decreasing the tank pressures and propellant flow rates after 62 seconds of firing. The resulting variations in the mixture ratio may have contributed materially to the rapid erosion. A faulty electrical connection was the probable cause of the ignition failure.

With the thrust-chamber lifetime indicated to be as little as 250 seconds it was agreed by Aerojet, Martin, and NRL that a means of lengthening this lifetime was required. Anodizing by a Martin process appeared to be promising, and both the repaired chamber C-10 and a new chamber, B-27, will be anodized. B-27 will then be used for qualification tests, and C-10 will be fired on "work horse" tankage for lifetime determination.

The sequence of individual tests comprising the qualification test program has been revised to the following:

1. a 10-second check firing,

2. a 60-second acceptance test firing,

3. a 115-second firing representing the flight firing,

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*P.V.R. No. 19, p. 1

†P.V.R. No. 19, p. 2

4. a 15-second firing representing the static firing,

5. a repeat of the foregoing sequence, and

6. repeated 115-second firings until failure.

Propulsion Unit No. 3 was completed and an acceptance test firing conducted. The performance was satisfactory but a pressure test following the firing revealed leaks to the outside of the thrust chamber. These leaks were localized and welded, and another 10-second firing was conducted on the chamber. Leaks were again detected upon pressure testing, and the chamber has been rejected for flight use.

Propulsion Unit. No. 4 is almost completed, with acceptance tests scheduled for the first week in August.

Tank fabrication by Aerojet has been progressing on schedule. One tank was lost during the later part of June because of an accident which caused a rupture. The tankage of the original qualification test unit was lost because of the aforementioned stress corrosion. A tank assembly which had been intended for use on Propulsion Unit No. 3 was rejected for flight use because of a weld which was necessary to correct for misalignment of the bottom end of the oxidizer tank. The assembly was redesignated for the qualification test unit.

The A. O. Smith Co., which is to supply some tanks to Aerojet, is having fabrication difficulties and also is being delayed because satisfactory tank heads are not available from Aerojet. However, the tank situation is not regarded as critical at this time.

Tests of second-stage flame impingement on the first-stage lox tank dome have been performed by Aerojet using a plastic fiberglass laminated insulating blanket on the dome. The blanket is to be placed over the dome to protect it from severe damage during separation in flight. Aerojet mounted the dome below a second-stage thrust chamber nozzle, and the blanket used was successful in protecting the dome. An acid leak which damaged associated hardware has temporarily halted these tests, but they will be resumed in August.

Third Stage

Grand Central Rocket Co.

The Grand Central Rocket Co. has begun the qualification test program for their third-stage rocket. A special coating was applied to the star points of the first two propellant castings to increase the resistance to cracking. After these castings were temperature-conditioned to 30°F, minor cracks in the coating (but not in the propellant) were noted. The next four motors were cast and coated at a lower temperature, and the cracking did not recur. The fuel separation problem noted recently* has not reappeared; closer tolerances in the ingredients and greater control of the propellant viscosity during casting appear to have eliminated this difficulty. The first statistical test firing of the qualification program was made on 30 July with a motor conditioned to 30°F. The total propellant weight was 381 pounds. The specific impulse at altitide was computed from the test data to be 240 seconds which, with the present mass ratio, will give the specification velocity increment. However, this specific impulse indicates a minimum due to firing at low temperature; the higher temperature firing should indicate a higher specific impulse.

*P.V.R. No. 17, p. 3, and No. 19, p. 4

The present firing schedule calls for two statistical test firings each at low, ambient, and high temperatures. If these show no difficulty, the temperature cycling of another six units will be started immediately, and the remainder of the statistical firings will be finished with these six rockets, which are presently being cast.

The Nigg Engineering Co. is presently fabricating altitude nozzles for the GCR third-stage rocket. Delivery will begin on 26 August and continue at the rate of four per week thereafter.

The Cooper Development Co. is having difficulty in delivering acceptable third-stage stainless steel chambers to GCR. The backup chamber source is the Western-Way Co., which is presently constructing chambers and expects to make an initial delivery during August. Meanwhile, there are enough available chambers from Cooper to permit initiation of the qualification testing. It is now anticipated that the GCR qualification test program should be completed by the third week of October.

Allegany Ballistics Laboratory

The Allegany Ballistics Laboratory has been testing small-scale (8-inch diameter) motors in a continued effort to find a means of overcoming the unstable burning experienced in the full-scale firings. Two approaches are being tried; one employs a paddle-type suppressor in the ported area of the rocket in conjunction with baffles embedded in the propellant web; the other employs chemical additives, e.g., potassium sulfate or aluminum oxide, dispersed in the propellant during mixing. The current tests indicate some promise with a rubberized suppressor, but no conclusive results are available as yet. Moreover there are indications that the aluminum oxide additive might eliminate the necessity for both suppressor and baffles. ABL expects to resume full-scale testing during August.

FLIGHT CONTROL

General

The stability of the TV-3 rigid-body aerodynamic loop has been analyzed. The Nyquist diagrams show that the static gain of the autopilot (ratio of engine deflection δ to vehicle deflection θ) should be lowered from the original value, 1.6, to 1.2. The least stable condition in first-stage flight under nominal performance conditions occurs at burnout, where the M-circle value is 2.6. The least stable condition in second-stage flight, with a nominal control system and with maximum tolerances on the aerodynamic parameters, occurs at ignition, where the M-circle value is 2.7.

A countdown test has been conducted on the mockup of the launching vehicle electrical system. Visual observation indicated that all electrical components operated satisfactorily; however, a rapid dropping of the second-stage battery voltage near the end of the countdown indicated that this battery had not the reserve capacity required. To increase the reserve capacity a relay has been added to shut down the second-stage hydraulic pump motor at cutoff of the engine. In addition, this added relay will now be used to delay arming of third-stage spin and separation circuitry until the time of second-stage engine cutoff. The electrical system mockup and vehicle wiring diagram are being modified to incorporate these changes. Another countdown test of the electrical mockup in conjunction with the controls system is now scheduled for completion before 15 August 1957.

The vehicle flight power batteries (identical in the first and second stages) have successfully passed vibration tests to 2000 cycles per second. This test completes all qualification tests on the flight power battery.

Guidance

The fifth gyro reference unit has been subjected to additional vibration tests by the Minneapolis Honeywell Regulator Co., which has been having difficulty producing shockmounts which give adequate isolation from vibration without deformation under acceleration.* This unit, the first to employ modified shockmounts, has not met the specified gyro drift rates at vibrations between 38 and 42 cps. This problem is still under investigation and does not affect the four units already delivered.† Two of these first four units, however, have been returned to the supplier. In one unit the yaw gyro failed, and in the other a subminiature tube failed. Units 3 and 4 have operated satisfactorily during the TV-3 horizontal controls tests and the engineering developmental tests.

Attitude Control

The modified‡ Vickers magnetic amplifier autopilot has failed to pass the qualification tests because the values of the capacitors used in it varied with temperature. In order to substitute capacitors which are not sensitive to temperature, a complete redesign of the space requirements is necessary. The weight of the magnetic amplifier with these additional modifications is almost the same as the present backup electronic amplifier. Delivery of the first modified unit is scheduled for 30 August. Meanwhile, the electronic amplifiers are on schedule for all vehicles through TV-4.

The first-stage roll jet actuator and nozzle assembly passed qualification tests on 13 July. This assembly‡ requires no increase in the actuator force. Acceptance tests have now been completed on units for all vehicles through TV-3. Controls tests on the first-stage roll mockup have been successfully completed with the new roll jet assemblies in combination with the TV-2 control system, and with the TV-3 control system including the Minneapolis-Honeywell gyro reference system.

"Live" tests of the first-stage gimbaled engine hydraulic servos have been performed during static firings of the first-stage engine. However, the results cannot be ascertained because of faulty instrument operation, and the tests have been rescheduled for the first week of August.

Flight Program and Staging

Three of the program timers delivered by Designers for Industry, Inc., (DFI) have now passed acceptance tests. Two of these have had their timing sequences modified in accordance with the new role of TV-3 and the TV-3 backup vehicle in the test program. The instability of the time-base oscillator of the program timer, which had been noted during the qualification vibration tests,** has been rectified and the qualification of the program timer is now complete except for the lifetime tests.

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*P.V.R. No. 13, p. 5, and No. 11, p. 7
†P.V.R. No. 19, p. 4
‡P.V.R. No. 19, p. 5
**P.V.R. No. 19, p. 6

A modification of the integrating accelerometer portion of the coasting time computer was necessary in order to meet the vibration specification for qualification.* The modification, consisting of increased support between the integrating gyro and the servo table, results in a weight increase of 2 pounds 2 ounces above the specification value for the first unit. This increase will be reduced to 0.75 pound for all units after the fourth, through the use of a magnesium casting in place of the present aluminum support. The results of the acceleration tests for qualification indicate that the computed coasting times do not meet the specification requirements under acceleration. Electronic Communications, Inc., (formerly Air Associates, Inc.) believes the deviation to be a function of the test equipment, not of the coasting time computer. However, they are requesting a modification of the specifications to cover the latest test results. If this is approved, the coasting time computer will be qualified except for the lifetime tests.

An instrumented mockup of the aft end of the vehicle second stage and the forward end of the first stage, connected by the explosive bolt system, has been used by The Martin Co. to test the explosive bolt and blast door action during first-stage separation. The instrumentation included high-speed cameras and accelerometers. Analysis of the test data will yield information about the disturbing forces due to the explosive bolt system which can be expected at first-stage separation.

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*P.V.R. No. 17, p. 6

THE SATELLITES

DESIGN, STRUCTURE, AND ASSEMBLY

Group 1 Satellites

Further tests* are being conducted on the pressurized internal instrumentation container for possible use in the Group 1 satellites. A test container has been equipped with (1) three battery modules which were first subjected to random vibration in all three planes at 10 g for 2 minutes, (2) a module containing a pressure gage, and (3) several dummy modules to take up the remaining space. This container, sealed at atmospheric pressure, was allowed to remain at ambient temperatures for 18 hours and then placed in an oven at 65°C, where it will remain for the life of the batteries while the battery voltage, the lid temperature, and the internal pressure are monitored. The primary object of these tests is to observe the pressure buildup due to the gasses released by the batteries, and thus to determine whether a relief valve will be required. Some information on the performance of the batteries will also be acquired.

Five pressurizable containers have been gold plated by Brooks and Perkins; one has been used in Group 1 prototype Satellite C and the others will be available as flight units if the use of a pressurized container is decreed by the results of continuing battery units.

Satellite B, with its separation mechanism replaced by a stainless-steel sleeve, has been subjected to the final design vibration and acceleration tests.† No structural failures occurred, and the satellite is therefore considered structurally sound. It is now undergoing thermal and vacuum tests which will be completed early in August.

Satellite C, considered to be identical in all respects to the flight units, has been completely assembled; it is now undergoing electrical tests which will be completed early in August and will be followed by the vibration and acceleration tests.

The first of the three Group 1 flight satellites has been shipped to Fort Belvoir for coating with silicon monoxide. The coating should be completed by 5 August, at which time the other two units will be shipped and the final assembly of Flight Unit No. 1 will begin.

Group 2 Satellites

The design of the Group 2 satellite is now complete. Since this satellite is very similar structurally to the Group 1 satellite, considerably fewer and less exhaustive tests will be necessary. The aluminum prototype assembled and tested at NRL‡ has been shipped to the State University of Iowa for further study. Further vibration tests will be conducted on this prototype at NRL in August, primarily to test the instruments.

*P.V.R. No. 17, p. 7; and No. 19, p. 7
†P.V.R. No. 17, Appendix A
‡P.V.R. No. 19, p. 7

A contract for the production of Group 2 satellite shells and structures will be awarded as soon as funds are available. The Group 2 satellite is now somewhat behind schedule.

Group 3 Satellites

The final design of the Group 3 satellite is not yet completed, and at present a delay of 1 month is expected, owing to the change in the test program which places a high priority on completion of the 6.44-inch satellites. A schedule has been formulated which indicates completion of the Group 3 satellites in time for the scheduled launching of SLV-3, but this schedule allows very little time for unexpected difficulties. However, it appears that fabrication of these satellites can be much more rapid than the fabrication of magnesium satellites, and this may result in a substantial time saving.

The base and cylinder of the magnesium internal instrumentation container will be constructed as an integral unit, and the four antennas will be fixed to the container. It appears that thermal isolation of the container will be necessary as in the case of the Group 1 container; this could result in a change in the presently contemplated 13-inch diameter of the sphere. The batteries will be housed in a pressurized can within the instrumentation container, and tests with individual batteries indicate that a pressure relief valve will be required on this can.

Group 4 Satellites

A 20-inch magnesium sphere (one of those used in the Group 1 testing) has undergone preliminary vibration tests* with the internal instrument package for the University of Wisconsin's radiation balance experiment. Two Group 1 antennas were also employed, with 1-inch titanium spheres (which are the sensing elements for the experiment) mounted on their ends. During these tests, the satellite stem fractured because of metal fatigue. However, this satellite had received a total of 10.6 hours of vibration, largely in the Group 1 testing. Such a failure is not to be expected in a flight unit, which will have received much less vibration—perhaps a total of one hour. These tests were resumed and completed with the instrument package in an aluminum satellite (the obsolete Group 1 Satellite A), and no structural failure occurred. Further tests will be performed following some modifications to the instruments.

An aluminum prototype of the radiation balance satellite has been shipped to the University of Wisconsin for test purposes.

6.44-Inch Satellites

Several design changes have been made in the six-antenna 6.44-inch satellite; e.g., the antennas have been reduced in diameter from 1/2 inch to 5/16 inch and shortened to 12 inches to eliminate the necessity for folding them in the launching vehicle, and two of the solar cells have been relocated. The fabrication of these satellites in aluminum is proceeding on schedule at NRL; one unit is completed (Figs. 1 and 2), two more will be completed by about 2 August, and the total of twelve (six test and six flight units) will be completed by about 11 September.

*P.V.R. No. 17, Appendix A

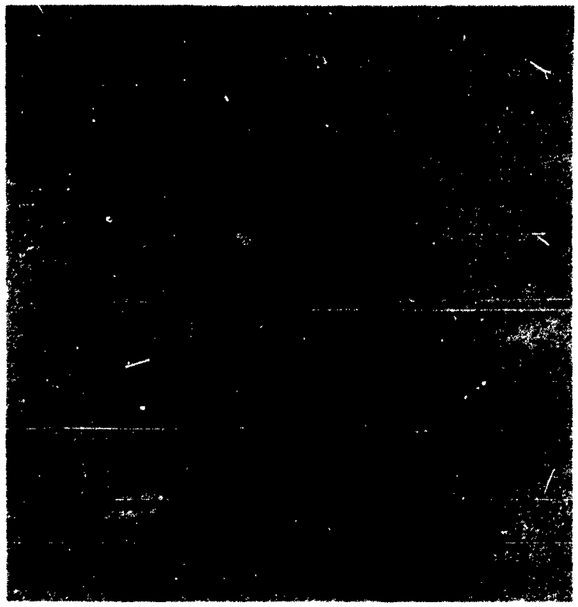

Fig. 1 - 6.44-inch satellite

Fig. 2 - Interior of 6.44-inch satellite

Preliminary vibration tests* were begun on the first completed unit but ceased when several failures were noted: (1) one antenna failed, (2) one separation strap bolt failed, (3) the locating-pin holes in the satellite's base were deformed, and (4) three internal Kel-F supports fractured. The antenna failure was due to insufficient tempering. Although the separation strap bolt was redesigned, this design has now been superseded by the new separation mechanism which does not employ these bolts. Inserts installed in the locating-pin holes have solved the deformation problem. The fractured Kel-F supports were replaced with new ones which met the design specifications, but when the vibration tests were repeated the same three supports again fractured, along with a fourth support. These supports will be strengthened before further vibration tests are conducted.

Effects of Spin Rocket Exhaust

Further analysis of the effects of spin-rocket exhaust products on the satellite surface† has been inconclusive. Organic analyses have disclosed a high-molecular-weight dimethyl siloxane—a commercial equivalent would be the Dow Corning series 500 silicone oil—which appears to occur in very small droplets on the satellite. The composition of the spin rocket fuel seems to eliminate this fuel as the source for the oil, and no silicone oil or grease was used in the vacuum system at the time of the test. Further investigation is required to determine the source of this oil. Meanwhile, means of preventing the combustion products from contacting the satellite surface, e.g., a removable shell, are being considered.

Satellite Separation Mechanisms

Timing checks have been made on the separation mechanisms for the 20-inch satellites, and the operation of the clocks has been found repeatable to within roughly one second at room temperature in both vacuum and atmospheric pressure. During the vacuum tests, however, the explosive motors failed to fire in five of thirteen attempts. Discussions with the Raymond Engineering Laboratories disclosed that the powder squibs had not been sealed, and thus moisture had been allowed to diffuse into the powder. The remaining squibs have been returned to Raymond to be corrected or replaced, and testing will continue upon their redelivery.

A check-out list has been compiled for ascertaining the adequacy of separation mechanisms in the field prior to flight.

The separation mechanism for the 6.44-inch satellite has been further revised to release the holding strap by means of retractable pins rather than explosive bolts; this revision required changes in the base of the satellite. Six 20-inch-satellite separation mechanisms have been returned to Raymond to be modified to this new design for use with the 6.44-inch satellites.

SCIENTIFIC EXPERIMENTS AND INSTRUMENTATION

Group 1 Experiments

During the vibration and acceleration tests on Satellite B, a variation in the rf power output of the Minitrack transmitter was noted. Investigation disclosed partial or intermittent

*P.V.R. No. 17, Appendix A
†P.V.R. No. 19, p. 8

contact of a ground rod with the lid of the container and of an aluminum foil shield with the walls of the container. When measures were taken to insure a good contact in both instances, the vibration was eliminated.

Measurements have been made on the satellite antenna system to determine the impedance presented to the Minitrack transmitter if one antenna is lost in flight; the length of the antenna line has been adjusted so that the transmitter operation would not be seriously affected by such an event.

The electronic modules for the Group 1 prototype Satellite C have been tested separately and are now interconnected in a test rack for system checks with external battery power. These tests should be completed early in August and the vibration and acceleration tests on Satellite C will begin at that time. The assembly and wiring of the electronic modules for the first Group 1 flight unit has begun and should be completed by mid-August. Assembly of the complete internal package will then commence, and electrical tests on Flight Unit No. 1 should begin early in September. Except for dynamic balancing, this satellite should be ready for flight by the end of October, some four months in advance of the anticipated launching date; the two additional Group 1 flight units follow the first closely, and all three will be available by the end of the year.

Group 2 Experiments

The rf system in the State University of Iowa Cosmic Ray satellite has been improved in several ways. A new command receiver has been developed with a balanced mixer, and the modulation on the local oscillator signal (taken from the Minitrack transmitter) now does not decrease the receiver sensitivity. A bridged-T filter now provides the necessary isolation to prevent jamming of the receiver input by the 108-Mc Minitrack transmitter radiation. The original antenna phasing network has been replaced by a lumped-constant circuit which is 3.4 ounces lighter and has smaller losses.

Tests on the command receiver network indicate that signal levels lower than -90 dbm would reliably actuate the receiver output relay, reading out the stored data and resetting the tape recorder. The signal level expected at ranges of 300 miles and 2000 miles are -60 dbm and -77 dbm, respectively, allowing a comfortable margin.

Group 3 Experiments

The design of the magnetometer sensing head by Varian Associates is now complete and electrical tests are underway. The weight of the sensing head has been reduced to 20 ounces, and the head and relays have satisfactorily passed environmental tests at NRL.

The use of special nonmagnetic mercury batteries in the Group 3 satellite has been abandoned because of anticipated fabrication and delivery problems, and a decision has been made to use Zn-AgO cells for all Group 3 instrumentation. These cells have been subjected to life tests after vibration at temperatures from -30°C to +74°C, and further testing is underway. The batteries will be housed in a pressurized can in the satellite instrumentation container, and tests of this can are also being conducted.

6.44-Inch Satellite Experiments

The 6.44-inch satellite (Figs. 1 and 2) has been designed with the primary object of providing reliable transmission for radio tracking purposes. To fulfill this objective it has two completely separate transmitter systems. One transmitter, battery powered, radiates by means of four antennas mounted in a turnstile arrangement. The power radiated by this transmitter is 10 milliwatts and the battery has a minimum life of two weeks. The temperature range over which this system will operate is 0°C to 80°C. The transistor limits the upper temperature and the batteries limit the lower.

The other transmitter, using two additional antennas mounted at the pole ends of the sphere, is powered by six solar cells. The power output is about 5 milliwatts. The life, barring catastrophic failures, should be in the order of years. The temperature range has an upper limit as required for the transistor. The lower limit is unknown. The output at the high temperature will decrease due to the reduction in output from the solar cells. In this regard the solar cells are conservatively rated and cover about twice the area originally planned. The cells are also covered by a quartz glass to protect them from erosion. When this glass is eroded by blasting, the cell output may be reduced by no more than 30 percent. The larger cell area and the quartz cover are detrimental from a weight standpoint but it is felt that the added reliability outweighs this factor.

Since temperature measurements of the satellite will be made, a study has been made of the effect of the solar cells on the prediction temperature of the satellite. The satellite emissivity can be determined to good accuracy. The absorptivity, on the other hand, will vary according to the aspect of the rotation axis with respect to the sun, since the cells are effectively black while the remainder of the satellite is only 15 percent black. The temperature difference resulting from the difference between the minimum and maximum absorptivities is about 10°C. This range could be reduced by making the remainder of the satellite black but, since the temperature measurements are made to determine if a major error in calculation has been made, any such change does not appear to be indicated.

The frequencies of the transmitter will be measured to give satellite temperatures at two points. The frequency-controlling quartz crystals in the transmitters are ground to provide a frequency change of 100 cps per centigrade degree of temperature change.

Measurements on the crystal frequency-temperature characteristic indicate that the ±5°C temperature tolerance claim should be achievable under all conditions of voltage, pulling factors, and circuit changes.

Since the six antennas and the six solar cells are symmetrically located on the satellite shell its spherical symmetry is quite good. Thus, in view of the long transmitter life possible with the solar-powered unit it appears that some air density data should be obtainable in the event that an orbit is achieved. In addition, it is expected that the linearly excited radiator may provide data from which ionospheric measurements may be inferred.

ELECTRONIC INSTRUMENTATION

TELEMETERING

PPM/AM Systems

A total of 16 of the 25 AN/DKT-7 telemetering transmitters ordered from the James Spivey Co. have been delivered and accepted. The transmitter and calibration for TV-5 has been shipped to The Martin Co.

Several minor modifications have been made in the AN/DKT-7 transmitter as a result of vibration tests. It is now proposed to vibrate all transmitters at 10 g for 2 minutes in each of three axes, as a preflight test.

All deliveries of ppm/am flight calibrators and spares have been completed by the Lemath Co.

Upon the redelivery of a video recording magazine, rejected by NRL as unsatisfactory for the third time, all deliveries of these units by the Wilkes Co. will be complete.

PWM/FM Systems

As a result of the revised launching vehicle test program, it has been decided to replace the dynamotor-powered pwm/fm telemetering transmitters in TV-3 and the TV-3 backup vehicle with the transistorized power supply "model 2A" transmitters. The resulting weight saving in each case is about 4 pounds. At the present time both types of transmitters are available for these two vehicles, and if the preflight tests with the transistorized version are successful, it will be used as the flight transmitter; the physical installation is the same for both transmitters. This will give an early flight evaluation of the transistorized power supply, which is being used in all subsequent transmitters.

A circuit designed to protect the transistorized power supplies from overvoltage is under development. It has two secondary beneficial features as well: it will regulate the filament voltage and the B+ voltage to the transmitter.

The progress on this circuit to date consists of a prototype laboratory model which performs satisfactorily with a 6-volt dc input. The circuit will be changed to the required 28-volt level as soon as the components are available.

Developmental work on the use of alternating current for the filaments in the pwm/fm transmitters has been completed and the next step is to test one of these units in the field open-loop with the pwm/fm ground station. If successful, this development will save some power loss as well as components, since the diode rectifier involved can be deleted.

FM/FM Systems

The transistorized power supply for the fm/fm transmitter package has been tested in the field and yielded clean recordings. A second supply is on stand-by in the event that a decision should be reached to modify another transmitter.

The Electromechanical Research Corp. has a difficult delivery schedule on the voltage-controlled subcarrier oscillators for the fm/fm telemetry system. In view of this, three oscillators have been borrowed from the Hoover Electronics Co. for environmental and electrical testing as a possible source of spares.

VEHICLE TRACKING

During this report period, three AN/DPN-48(XE-1) beacons were received from Melpar, Inc. These were Serial No. 6 (S-band), No. 7 (C-band), and No. 8 (S-band). Two of these required further work by a Melpar representative before they were considered in conformity with the specifications. A C-band rf head has also been received from Melpar. It was found that the preselector cavity used in this unit was dimensionally and electrically out of tolerance. Replacement of the cavity has been arranged.

Two C-band DPN-48's have been shipped to The Martin Co.; both were tested and accepted by Martin in the presence of an NRL representative. One has been allocated for TV-4 and the other for the TV-4 backup vehicle. Another AN/DPN-48 beacon has been rejected, at NRL's request, for intermittent sensitivity. This unit is Serial No. 2 (C-band), allocated for TV-3. It is now undergoing repair at NRL, which has requested that Serial No. 7 (C-band), a magnesium unit, be used in TV-3 in its place.

Serial Nos. 6 (S-band) and 8 (S-band) are also at NRL to be repaired. No. 6 is standing by to be checked out at S-band for satisfactory operation in the "as-received" condition. No. 8 has been made satisfactory at S-band and has been converted to C-band by using the C-band rf head from Serial No. 4. This unit will soon be ready for delivery to The Martin Co.

RANGE SAFETY

Two more AN/ARW-59 command receivers have been delivered by the Connecticut Telephone and Electric Co. Production of these receivers by the company has started, but no delivery schedule is available as yet.

The specifications for the transistorized decoder to be used with the command receivers have been modified to cover the use of selenium transistors. This was necessary in order to pass the temperature tests. The decoders for TV-5 will be delayed about two weeks; however, no difficulty is expected as a result.

THE MINITRACK SYSTEM

GROUND STATION ESTABLISHMENT

It now appears that all Prime Minitrack Stations excepting the Australia Station will be ready for satellite tracking by 15 September. The Blossom Point Station is now in operation, and the calibration will be complete in the near future. The Antigua Station has been checked out electronically and, despite some shipment damage to the trailer and the lack of some minor items, is presently capable of satellite tracking. The electronic checkout at the Fort Stewart Station is now underway, as is calibration of the San Diego Station. The trailer installations are substantially complete at Havana, Quito, and Lima. The trailer at Santiago is now being unpacked, and word that the trailer for Antofagasta has arrived is expected at any time. The trailers for the Grand Turk installation are scheduled to arrive on 20 August. The Army station personnel have arrived at Fort Stewart, Havana, Quito, Lima, Santiago, and Antofagasta. The NRL station scientist has arrived at Havana, and the others will have arrived at their stations by about 26 August.

The changes in the launching vehicle test program require changes in the Antigua and Grand Turk Stations. Because of the increased range of the third stage resulting from the use of a minimum satellite payload rather than a heavy instrumented nose cone, the Mayaguana Station has been eliminated. The Antigua and Grand Turk Stations are being expanded.

The Grand Turk installation will utilize two sets of antennas. One set will cover the azimuth angles from 324 to 24 degrees. The other will cover the angles from 23 to 83 degrees. The vertical angle of the radiation expected at Grand Turk is about 30 degrees.

The Minitrack equipment first tracks on the west antennas and is then switched to the east antennas when the transmitter position is suitable.

At Antigua another set of antennas is adjusted to cover azimuth angles of 308 to 008 degrees true. This set of antennas covers all of the trajectory covered by the Grand Turk antennas. The vertical angle of the radiation received at Antigua is about 10 degrees, so the angular accuracy of the Antigua east antennas will be degraded by reflected signals.

The Antigua equipment is switched from the west antennas to the prime antennas when the transmitter passes into the angular coverage of the prime antennas centered at 25 degrees true, and then to the east antennas. These antennas are included to give additional trajectory coverage.

A trailer loaded with equipment for antenna installation is due at Grand Turk on 20 August. Equipment for antenna installations at Antigua will be shipped by air.

SYSTEM CALIBRATION

Calibration by moon reflection is presently planned for all South American stations. This system will also be used for checking the calibration of all other stations except Australia.

The tests run so far have involved use of the Diana radar at Fort Monmouth, New Jersey, with a modified Minitrack station at Blossom Point. The results to date are promising. The Evans Signal Laboratory is presently building a 151.11-Mc circularly polarized feed for their 50-foot dish antenna, to determine whether the reflected signal can be improved by this modification.

Agreement between the Signal Engineering Laboratories (USASEL) and NRL has been reached in regard to this project. The present plans are as follows: USASEL is to furnish a building, personnel, and a 60-foot dish antenna. NRL is to furnish the antenna feed (contracted by USASEL) and the transmitter. In this regard attempts are being made to purchase a 50-kw fm transmitter. At the same time a backup transmitter program is being pursued at NRL.

A tentative date of 1 October has been set for activating this system. The transmitter is presently controlling the schedule but it is doubtful that the dish will be delivered by 1 October.

DATA PROCESSING

TELEMETERED DATA

The recording and reduction systems of the Automatic Recording and Reduction Facility (ARRF)* for telemetered data have been completely assembled at Radiation, Inc. (Orlando, Florida) and are undergoing final tests. It is expected that the Digital Data Recording System van will be delivered to the NRL Telemetry Pad at Cape Canaveral in early August (in time for recording data during the static firing of TV-2). With the possible exception of the linearizer and its associated equipment the Digital Data Reduction System is expected to be in operation at Orlando by the middle of August. The linearizer, which was built by Radio Corporation of America (Camden, N. J.) under sub-contract to Radiation, Inc., has exhibited operating troubles after installation in the ARRF system. RCA engineers have tentatively diagnosed the problem and are modifying the linearizer as rapidly as possible.

ORBITAL DATA

The Vanguard Computing Center was officially opened on 2 July 1957. Operation of the IBM 704 for orbit determination and prediction was demonstrated by calculation of a preliminary elliptic orbit from simulated Minitrack observations. As part of the demonstration, the predicted positions of the satellite at one-minute time intervals for a period of 24 hours were presented sequentially in a 3-minute period on cathode-ray-tube display as points on a map to show how the satellite motion would appear on a Mercator projection of the earth.

The group of IBM mathematicians was augmented by three programmers to be certain that a satisfactory program for orbit computations would be completed and checked out with simulated observations prior to the flight firing of TV-3. Sufficient experience was gained from the demonstration presented at the Computing Center opening so that no additional "dry" runs simulating a satellite launching operation were made in July.

The Teletype installation for communication between the Computing Center and the Vanguard Control Center at NRL was completed the last week in July. There are now available three Teletype lines with associated terminal equipment as well as a private telephone line.

THIRD-STAGE FIRING PREDICTION

The AN/FPS-16(XN-1) radar was delivered to Patrick Air Force Base the second week in July. The radar antenna pedestal was mounted two weeks later, as soon as the concrete platform at the site was ready to receive it. The fourth week in July the stabilized pad for the trailer equipment was completed but no power was available. The fifth week the radar trailer and the spare parts van were moved to the pad, and three motor-generator sets were placed in operation to supply power until permanent power lines are installed late in August. An interim scheme for checking the radar antenna alignment

*P.V.R. No. 17, pp. 24-27

will probably have to be used prior to the flight firing of TV-2, since the boresight tower installation is not expected to be complete until late in August. One of the optical digital encoders for angle was damaged in shipment and returned to RCA (Moorestown) for repair or replacement. The XN-1 radar is expected to be ready for tracking TV-2 in flight.

During the first part of July the AN/FPS-16(XN-2) radar on Grand Bahama Island was operated in conjunction with its boresight tower and the transmitter was operated into a dummy load. Some special wave guide parts had to be made and installed before the system could radiate through the antenna and track targets. This work was completed the fourth week in July and some tracking runs were made using balloon-borne spheres as targets. The radar synchronizer chassis is being built at Moorestown and will probably be installed in the XN-2 the week of August 19, in time to permit simultaneous tracking of the C-band beacon in TV-2 by both the XN-1 and XN-2 radars without causing interference with beacon operation.

It had been expected that digital impact prediction would be available for the launching of TV-2, but it now appears that this may not be possible: the cable required for digital transmission of radar data from the XN-1 site at PAFB to the IBM 704 computer at Cape Canaveral probably will not be completed in time. The digital data transmission equipment for the XN-1 radar will be delivered the first week in August from the Milgo Electronic Corporation (Miami, Florida). The delivery of this equipment has been delayed because the instrumentation van to house it was not made available at an earlier date. The digital data receiving equipment for use with the IBM 704 will probably be delivered the second week in August.

In view of the above delays, the ground-controlled third-stage firing system will probably be delayed about a month. It should still be ready in early October so that a complete system check-out can be made before the launching of TV-3.

RANGE OPERATIONS

Field inspection of the TV-2 tankage and lines disclosed excessive dirt and chips in the propellant and gas systems. A subsequent check of the X-405 engine disclosed similar dirt within the engine pumps, valves, lines, etc. Inasmuch as no complete field maintenance facility was available, this engine, S/N-5C, was removed and replaced with a new unmounted engine, S/N-9.

Because it could not be determined how the dirt got into TV-2, the TV-2 backup vehicle was similarly disassembled at the Martin Co. plant and inspected. Dirt was also found in this vehicle. The engine, S/N-7, was removed and replaced with engine S/N-8; a cleaning procedure was drawn up and the tanks and systems were cleaned at the plant. Upon verification of its adaptability, the cleaning equipment was flown to AFMTC and TV-2 was cleaned. The TV-2 vehicle has been reassembled and ground tests have been started. The launching of this vehicle is now scheduled for 27 August.

CONFIDENTIAL

Naval Research Laboratory. Report 5020 (CONF.) PROJECT VANGUARD REPORT NO. 20 - PROGRESS THROUGH JULY 31, 1957 (Unclassified Title), by Project Vanguard Staff, 19 pp. September 16, 1957.

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